is related to collagen distribution and therefore may allow 3D assessment of collagen distribution in non-calcified AC. In this experimental setting, full staining was achieved in 36 hours. This is a first step towards 3D quantification of collagen distribution with in vitro AC samples and in small animal joints.

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ACCURACY OF COMPUTED TOMOGRAPHY ARTHROGRAPHY TO DETECT CARTILAGE DEFECTS IN THE OVINE KNEE

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Purpose: Naturally occurring cartilage defects of the knee have been described in sheep. The objective of the current study was to assess the accuracy of computed tomography arthrography (CTA) to detect cartilage defects in the ovine knee.
Methods: Animals and imaging: Hindlimbs (n = 28) were collected from crossed Texel ewes euthanatized for reasons other than hind limb lameness. Knees were injected with 20 ml of diluted contrast medium (6 ml of Hexabrix® diluted in 14 mL saline) through a needle placed in the femoro-patellar compartment of the knee, and were flexed and extended 100 times to provide a homogeneous coating of the articular surfaces. The limbs were examined with an Emotion 6 (Siemens). Acquisition protocol was: 130 KV, 80 mAs, pitch 0.4 collimation 0.63 mm and rotation time of the tube 0.6s. Images of 0.63 mm were reconstructed with an increment of 0.3mm. CTA was also performed in two living sheep (4 hindlimbs) under anaesthesia to test the feasibility of the technique. The limb was hold in forced-extension. After imaging, the sheep were euthanized and hindlimbs were collected.
Macroscopic assessment: Knee joints (n = 32) were disarticulated. The distal articular surface of the femur, proximal articular surface of the tibia and articular surface of the patella were examined by gross observation. Macroscopic scoring was performed following OARSI recommendations: score 0 for intact cartilage surface; score 1 for surface roughening; score 2 for deeper defects (fibrillation, fissures) not involving the subchondral bone (SB); score 3 for erosions down to SB (less than 5 mm diameter); score 4 for large erosions down to SB (more than 5 mm diameter).
Histological assessment: Samples were harvested from all sites with macroscopic lesions and from randomly selected macroscopically intact areas. Samples were processed and stained (Toluidine blue). Cartilage structure was scored blindly (from 0 to 10) according to OARSI recommendations.
Analysis of CT scans: Images were analysed blindly by two observers. One observer repeated the blinded assessment one month later to determine intra-observer reproducibility. A score of 0 was given when a sharp line of contrast material was identified on the cartilage surface, without substance loss. A score 1 was defined by a loss of the sharp and smooth contour of the cartilage surface. A score 2 was defined by the penetration of contrast material within at least the superficial half of the cartilage thickness but not to the SB. Score of 3 and 4 were attributed when this penetration reached the SB on respectively less and more than 5 mm diameter.
Statistics: Spearman's rank order test was used to assess correlation between macroscopic and histological scoring. Sensitivity, specificity, positive predictive value and negative predictive value were calculated by using gross anatomy as gold standard. They were assessed only for the sites where histopathology confirmed the macroscopic classification of defects (for example confirmed that a score 2 defect assessed macroscopically was a partial defect not involving the SB at microscopy, while a score 3 defect was a full thickness defect). Inter-observer and intra-observer agreement were assessed by using Kappa statistics.
Results: 106 histological samples were processed. There was substantial agreement between macroscopic examination and histological scores for structure (Spearman correlation coefficient 0.75; P 0.000). 83 samples (including 40 score 0, 16 score 1, 25 score 2 and 2 score 3 defects) had their macroscopic scoring confirmed by histology. CTA sensitivity and specificity were respectively 86.12% +/-1.20 and 94.44%+/-0.56% to detect over-all cartilage defects (no defect versus defect). The positive and negative predictive values were 94.50%+/-0.37 and 86.10%+/-0.89. There was substantial agreement between scores at macroscopic examination and those at CTA (Spearman correlation coefficient: 0.84 (observer 1), 0.82 (observer 2-lecture1), 0.83 (observer 2-lecture2); $P < 0.0001$). Inter- and intra-rater agreement was good (Kappa value: 0.67 and 0.93 respectively). Examples of score 2 and 3 defects are shown in Figure 2. In living subjects, two difficulties were encountered: breathing movements and limb positioning (Fig. 1). However, all seven score 2 defects present in the living subjects were accurately identified while two lesions of score 1 were not seen.
Conclusions: CTA is an acceptable non-invasive imaging technique to detect naturally occurring cartilage defects in the ovine knee. This technique can be applied in living animals.

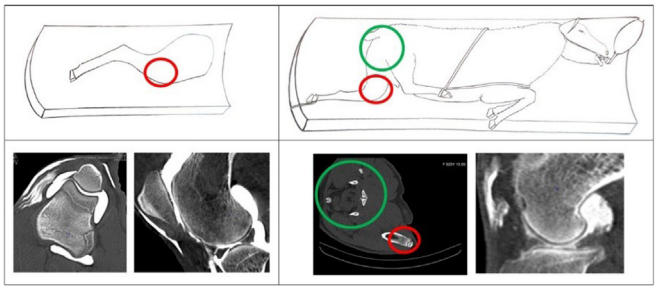

Fig. 1. Imaging of a cadaver knee (left) and a knee in a living animal (right). In lateral recumbence, despite the forced extension of the limb, the pelvis remained in the acquisition field; this affected the quality of the image since pelvis, soft tissues and knee attenuated the x-rays before they reached the detectors.

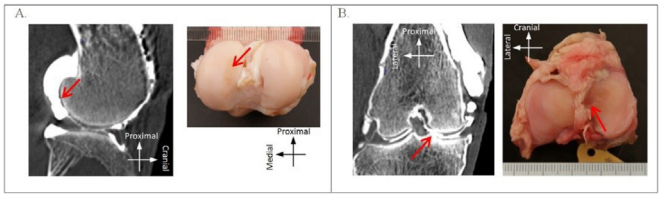

Fig. 2. Examples of cartilage defects. (A) a score-2 defect on the medial femoral condyle, (B) a score 3-defect on the axial aspect of the medial tibial condyle.

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BIOCHEMICAL CARTILAGE PROPERTIES IN A SHEEP MODEL - VALIDATION OF ZONAL T2 MAPPING ASSESSMENT

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Purpose: Articular cartilage lesions are a common pathology and spontaneous repair capacity of hyaline cartilage is limited. Hence there is a higher risk of developing osteoarthritis (OA) in the injured joint. The ability to detect this progressive pathology of the joint at an early stage is important for therapy planning. Surgical procedures like matrix associated autologous chondrocyte implantation (MACI) or microfracturing (MFX) of cartilage defects are treatment options for cartilage regeneration. In addition to a high-quality follow-up visualization after cartilage repair procedures, MRI can help to understand not only the development of OA but can also evaluate healing steps after cartilage repair procedures non-invasively. T2 mapping with very high resolution at 7T might play an important role in understanding the development of OA and of integration processes after cartilage repair procedures in the future. Especially the zonal (e.g. differentiation in between a deep and superficial cartilage layer) has been shown very high potential in quantitative T2 mapping, nevertheless with still a lack of histological prrof. The purpose of this study is to determine the zonal characteristics of articular cartilage (healthy and OA) and cartilage repair tissue of the femoral condyle in a sheep model, using biochemical MRI by means of quantitative T2-mapping.
Methods: Three groups of sheep were enrolled in this study. One group represented healthy cartilage (n = 24), one group represented a model of osteoarthritis of the femoral condyles (post meniscectomy) (n = 22) and one group had induced cartilage defects at the femoral condyle treated by MFX (n = 10). MR scans were achieved at 7T MR whole body system (Magnetom, Siemens Healthcare, Erlangen, Germany) using a twenty-eight-channel transmit/receive knee array coil. T2 relaxation maps were measured with ultra-high resolution sagittal multi-echo

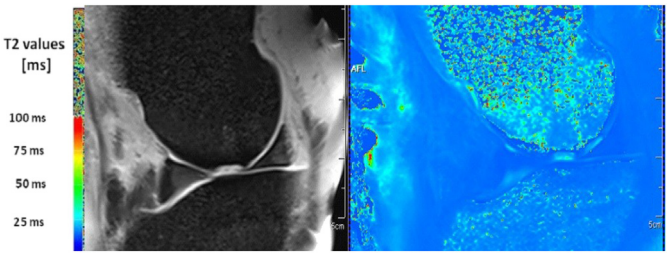
spin sequence. A semi-automatic region-of-interest analysis was performed for specific areas (healthy cartilage, area of OA, region of MFX). To allow stratification with regards to the anatomical (collagen) structure, subregional analysis was carried out (deep - superficial cartilage layer). Statistical analysis-of-variance was performed.

Results: In healthy cartilage values were 56,76 ms (SD 14,44) in the superficial layer and 41,21 ms (SD 18,35) in the deep layer. The knees with OA showed results of 56,51ms (SD 14,52) in the superficial layer and 49,05 ms (SD 18,38) in the deep layer. After MFX, results for T2 averaged at 61,33 ms (SD 21,18) in the superficial layer and 53,35 (SD 21,89) in the deep layer. Comparison between layers within each group and (statistical) comparison between the groups showed that the superficial layer does not vary significantly between the groups, whereas the deep cartilage zone varies in between the groups. Most important, the increase of T2 values between deep and superficial zone showed a clearly significant difference in between the different groups and was able to differentiate in between healthy cartilage, induced OA and cartilage repair tissue after MFX (Table 1).

Conclusions: Comparing ultra-high field MR T2 values between healthy cartilage, OA and cartilage repair sites at 7 T underlines the known fact that healthy cartilage is defined by a significant increase of T2 values between deep and superficial zone. With the used sheep model using T2 mapping, differences between healthy cartilage, OA and cartilage repair sites are detectable based on their zonal appearance. Hence, its application can help to evaluate cartilage repair procedures or therapeutical approaches in OA at the one hand and prove the value of ultra-high field cartilage T2 mapping for diagnosis and follow-up imaging in the future on the other hand. This evaluation is supposed to be a step towards a more detailed understanding of high resolution zonal imaging of cartilage after repair procedures or in an OA model

Table 1

	T2 ms Superficial (SD)	T2 ms Deep (SD)	p-values
Healthy cartilage	56,76 (14,44)	41,21 (18,35)	$p < 0.001$
OA	56,51 (14,52)	49,05 (18,38)	$p < 0.05$
MFX	61,33 (21,18)	3,35 (21,89)	$p > 0.05$



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ANKLE DISTRACTION AS A TREATMENT FOR END STAGE OSTEOARTHRITIS: FOLLOW-UP AT 10 YEARS

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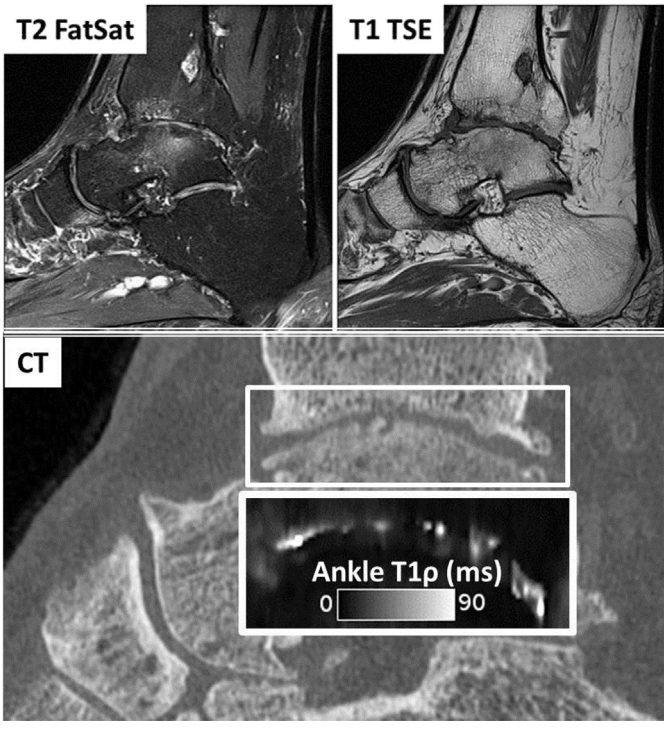
Purpose: End-stage osteoarthritis (OA) in weight-bearing joints is a painful and debilitating disease that is often treated by total joint replacement. Ankle OA is more frequently of post traumatic origin (70–80%). Patients under 50 years of age present a particularly difficult population to treat for post-traumatic osteoarthritis (PTOA). Ankle arthrodesis is an accepted definitive treatment in the young PTOA population, but there is a significant incidence of adjacent joint arthritis and functional limitations, without any subsequent options should failure occur. Alternatively, results and survivorship of total ankle arthroplasty (TAA) are not as predictable as for hip and knee replacement. Therefore this young active population is at risk for early revision of the implant, which is fraught with complications at repeat surgery and subsequent performance falling short of primary total joint reconstruction results. A desirable alternative is natural joint preservation by restoring the joint space with joint distraction arthroplasty using external fixation. This controlled trial follow-up, 10 years after surgery, demonstrates the potential of ankle distraction in reversing the painful disease process of OA and in prolonging natural joint function.

Methods: Thirty-six patients were enrolled who underwent ankle distraction surgery between December 2002 and October 2006. Inclusion criteria included: (1) symptomatic isolated, unilateral Kellgren-Lawrence grade 3-4 ankle OA; (2) skeletally mature to age 60 years old; (3) failure of non-surgical treatment for more than a year, including 3 months of continuous treatment with nonsteroidal antiinflammatory drugs and 3 months of unloading treatment; (4) ability to maintain extremity non-weight-bearing using ambulatory aids. Excluded were patients with serious co-morbidities, those with contralateral OA, and those with significant hindfoot or tibial misalignment, or with a current history of alcohol or drug abuse. IRB approved consent was obtained. Patients were evaluated by an independent clinical investigator and were asked to complete the Ankle Osteoarthritis Scale (AOS) and the SF-36 surveys. Radiological evaluations included plain radiographs, CT scans and ankle MRIs. Patients who were not able to return for a clinic visit were offered a survey evaluation including the AOS, SF-36 and basic health designed to replace the clinical interviews.

Results: From a total of 36 patients, data is available on 27 patients (77%) and one passed away. Fourteen patients still have their native ankle while 13 were fused or converted to TAA. Patients who ultimately required ankle fusion or TAA showed early signs of distraction failure. At 2 year follow up, they demonstrated lower functional scores (average AOS of 49 ± 17, $p < 0.05$) compared to patients with native joints at the same time point (average AOS of 33 ± 25). Even in distraction failure cases when patients elected to proceed with ankle fusion or ankle replacement, they still experienced the clinical benefit of the conversion surgeries and demonstrated significant improvement of the SF-36 Physical Component Scale (39 ± 3.8 compared to 36 ± 8.9 at baseline $p < 0.05$). This indicates that a history of ankle distraction surgery does not later complicate conversion surgeries or in any way limit patients' physical improvement. Imaging results show cartilage and subchondral bone in homogeneities have returned to differing degrees in native ankles at 10-year follow-up.



T2 FatSat shows bone metabolic activity throughout the midsubstance of the talus. A flattening of the talar dome is accented by posterior tibial